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During the period covered by this contract, technical advances were made in the general area of describing image textures in terms of the spatial distribution of local features, such as edges, in the texture. The first contribution concerned the theoretical development of a minimal error onedimensional edge detector for image models which can be used to describle textures. The second contribution was a comparative classification study of texture statistics derived form grey level and edge cooccurrence matrices. The third contribution was the development of a new computational tool for analyzing textures, called a polarogram. The polarogram is a rich source of directionally sensitive texture statistics which are invariant to image orientation. This research was documented in seven reports and papers.

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THEORETICAL ANALYSIS OF MODELS FOR TEXTURE

Larry S. Davis

1. RESEARCH OBJECTIVES

The research objectives of this project include the following:

1) Developing formal models for the detection of local image features such as edges and lines in image textures.

2) Developing formal models for the analysis of statistical properties of the distributions of such local features in image textures.

3) Applying the theoretical analyses developed in the efforts associated with (1) and (2) to the discrimination between classes of real image textures.

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2. STATUS OF THE RESEARCH EFFORT

This research effort was initiated on March 1, 1979. Since then, a substantial number of accomplishments have been achieved. These include:

1) The development of a theoretical model for the optimal detection of edges in textures. The analysis is based on a formal model of textures which describes the size and color of texture pieces along an arbitrary line through the texture. Given such a model, we have developed a minimal error edge detector which is based on applying an edge operator to an image texture and then marking edges by a combination of thresholding and local maxima selection. This research utilizes a wide variety of mathematical tools, including random geometry, probability theory and decision theory. We are now in the process of designing processes which will apply these theoretical results to the analysis of real images so that edges can be reliably computed even for images containing a mosaic of different textures.

2) A comparative classification study was performed which compared texture statistics derived from grey level cooccurrence matrices with those derived from cooccurrence matrices based on the distribution of local image features, such as edges and lines. The results of this classification study were consistent with previously reported results in that the statistics based on edges were more successful at discriminating between natural textures than were the statistics based on grey level.

3) A new tool for image texture analysis called a polarogram was developed. The motivation for developing the polarogram was to produce a tool which could generate statistics which were sensitive to differences in the structure of image textures as a function of directionality, but which were, at the same time, invariant to the orientation of the texture in the field of view. These two goals, sensitivity to directionality and invariance to orientation, have not been sufficiently attended to in the past. A polarogram is a polar plot of a directionally dependent texture statistic as a function of direction. Features of the polarogram which are invariant to rotations of the polarograms can then be shown to be invariant to the orientation of the image texture. Experimental results indicate that such polarogram statistics are quite powerful for texture discrimination.

3. WRITTEN PUBLICATIONS

1. A comparative texture classification study based on generalized cooccurrence matrices (L. Davis, B. Clearman and J.K. Aggarwal), IEEE Conf. on Decision and Control, Miami, FL., Dec., 1979.

2. An empirical evaluation of generalized cooccurrence matrices, (L. Davis, B. Clearman and J.K. Aggarwal), under revision for publication in the IEEET-Pattern Analysis and Machine Intelligence, (note: this is an extended version of (1) for journal publication.)
3. Edge detection in textures (L. Davis, A. Mitiche), to appear in Computer Graphics and Image Processing, 1980.
4. "Generalized Cooccurrence", (L. Davis), to appear in Computer Texture Analysis, Ed. R. Haralick, Plenum Press, 1980.
5. Polarograms: A new tool for texture analysis (L. Davis), accepted for publication in Pattern Recognition.
6. Edge Detection in Textures - Maxima Selection (L. Davis, A. Mitiche) to appear in Computer Graphics and Image Processing.
7. Texture analysis using edge cooccurrence, Proc. MICOM Workshop on Imaging Trackers and Autonomous Applications for Missile Guidance, Redstone Arsenal, AL., Nov., 1979.

4. PROFESSIONAL PERSONNEL

1. Larry S. Davis, Assistant Professor and Principal Investigator.
2. Amar Mitiche, Graduate Research Assistant, Ph.D. Candidate.
3. Simon Yam, Graduate Research Assistant, Ph.D. Candidate.
4. Russel Still, Graduate Research Assistant, M.A. Candidate
5. Bo Clearman, Master's thesis in Computer Science: A comparative texture classification study using generalized cooccurrence matrices, degree granted: December, 1979.

5. INTERACTIONS

1. Delivered paper entitled "Optimal edge detection in textures" at Image Modelling Workshop, Chicago, IL., August 1979.
2. Delivered paper entitled "Texture analysis using edge cooccurrence" at MICOM workshop on "Imaging trackers and autonomous applications for missile guidance" Redstone Arsenal, AL., November 1979.
3. Delivered paper entitled "A comparative study of texture classification based on generalized cooccurrence" at the IEEE Conf. on Decision and Control, Miami, FL., December, 1979.